Chemical and Aerosol Characteristics of Asian Outflow as Observed during INTEX-B and TRACE-P

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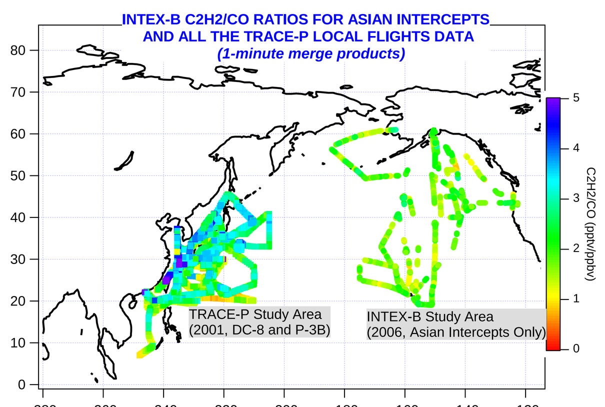
Introduction

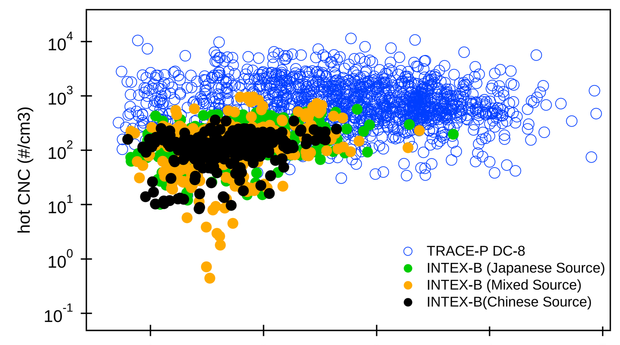
INTEX-B was conducted in the spring of 2006 investigate the transport and transformation of gases and aerosols on transcontinental/intercontinental scales and assess their impact on air quality and climate (http://cloud1.arc.nasa.gov). The field experiment was conducted in two phases: the first was to examine the outflow of pollution from Mexico City and was centered in Houston, TX, whereas the second (April 17-May 15) was based out of Hickam AFB, Hawaii and Anchorage, AK and was designed to examine the outflow of pollution from Asia. In this presentation, we analyze data from the second phase of INTEX-B to characterize Asian outflow as a function of age (C_2H_2/CO ratio) and vertical location (0-2, 2-4, 4-6, 6-8, and >8 km). We use airmass trajectories to identify the primary Asian continental source regions that influence atmospheric composition within the Northeast Pacific region. In addition, we compare INTEX-B vertical profiles of trace gas and aerosol species with similar measurements recorded just off the Asian coast during 2001's TRACE-P experiment to evaluate changes in species concentrations/characteristics during the ca. 10-day transport period between the two regions.

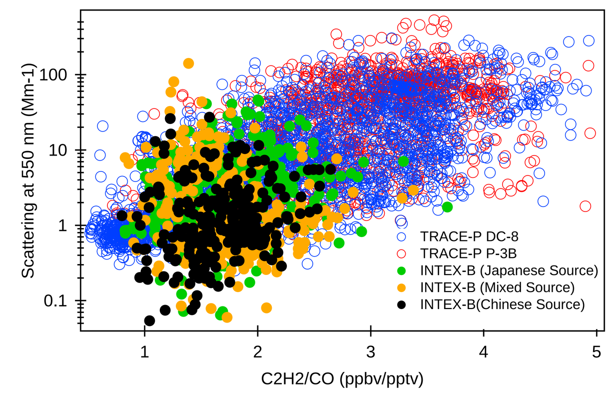
We intend to continue this preliminary analysis and add some in-depth analysis of plumes from various sources and compare them to fresher plumes encountered during TRACE-P. We plan include data recorded aboard the C-130 during INTEX-B off the west coast of the United States to further examine the evolution of the gases and aerosols of transported from Asian across the Pacific.

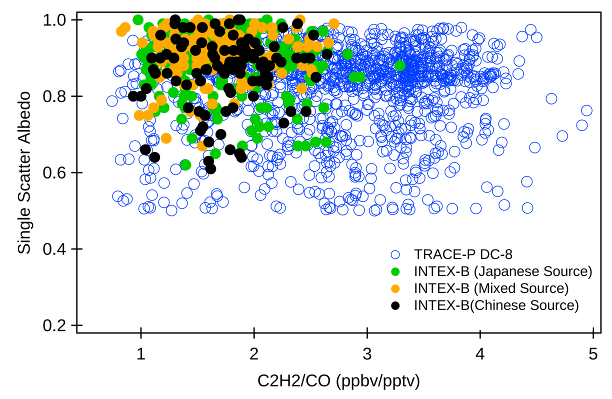
Chemical Aging

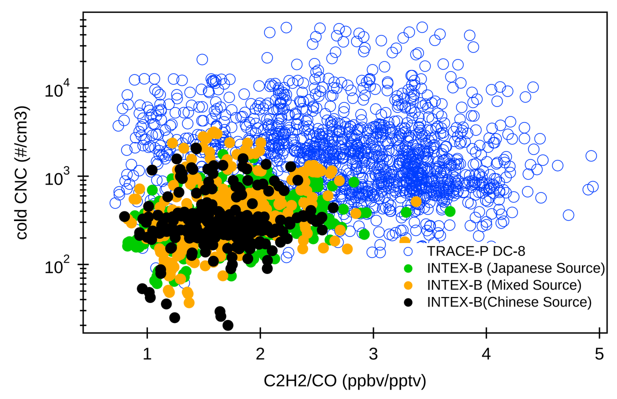


Plot of the C_2H_2/CO values for INTEX-B for the Asian encounters plotted with the same data for TRACE-P. The TRACE-P data is for both the P-3 and the DC-8 for the local science flights during TRACE-P.



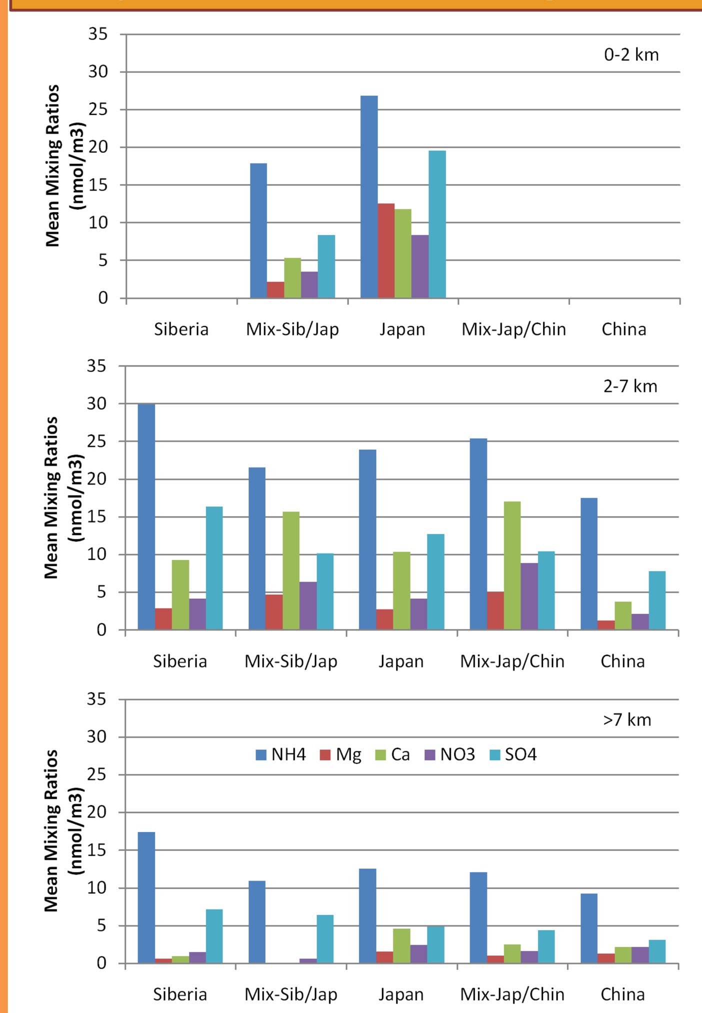






The ratio C_2H_2/CO is often used to look at the age of an airmass due to the fact the C_2H_2 and CO have common anthropogenic sources and the C_2H_2 has a much shorter lifetime than does CO. A C_2H_2/CO ratio > 5 implies a fresh plume, whereas a ratio < 2 is indicative of aged, photochemically processed air. The plots in this section show the C_2H_2/CO ratio plotted against scattering, hot and cold CN, and single scatter albedo for the INTEX-B data with the similar data plotted for TRACE-P. The plots show that the Asian air encountered during INTEX-B was photochemically processed prior to being sampled and that it exhibits little to no correlation with the plotted parameters. Furthermore the range of C_2H_2/CO values for the INTEX-B data ranges from 1-3 and that the data is consistent with aged air encountered during TRACE-P

Comparison of Source Regions With *Jordan et al.* [2003]



For the TRACE-P analysis, *Jordan et al.* [2003] as well as other articles used a four source classification scheme to group the near shore data into source regions. They were northern Asia (NNW), west (WSW), Southeast Asia (SE Asia), and channel. The channel data was only present below 7 km and was set apart due to its strong enhancement of Ca^{2+}, a tracer for dust. For our analysis, the Mix-Siberian/Japanese and the Japanese source regions are closest to the NNW group, the Mix-Japanese/Chinese group is closest to the channel group, and the Chinese group is closest to the SE Asia source. The Siberian source region was not sampled during TRACE-P since the limit on aircraft sampling during TRACE-P was about 50 N.

Therefore we did a plot similar to Figure 2 in *Jordan et al.* [2003] to examine the mean chemical signatures of water-soluble aerosols in each source region. Unfortunately, for the lowest layers, less than 2 km, we only sampled air from the mixed-Siberian/Japanese and the Japanese source regions. The Japanese source region shows more anthropogenic pollution species than does the more northern Siberian/Japanese source region.

The middle and upper troposphere shows interesting findings that will require further study to elucidate. The Siberian source region has the largest concentrations of NH_4^+ and $SO_4^=$, both of which are products of anthropogenic processes. Further work will be performed to determine the origin pollutants found within the Siberian air masses.

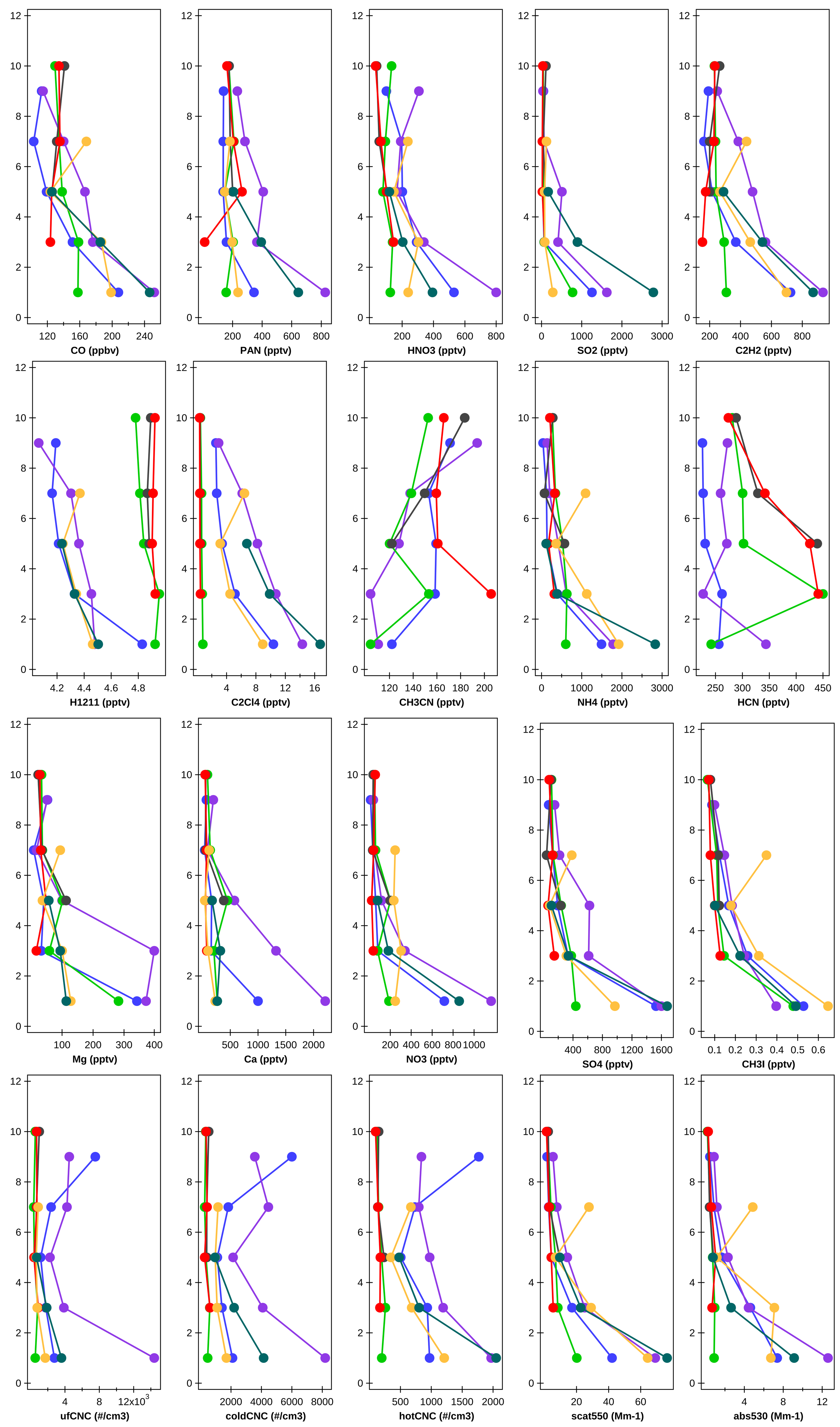
INTEX-B Asian Intercept Data - Source Regions

During INTEX-B we encountered a multitude of plumes originating from Asia. Using the Florida State back-trajectory analysis, we found that there were 3 primary source regions, which we denote as Siberian, Japanese, and Chinese. In addition we define 2 overlap regions (Mix-Siberian/Japanese and Mix-Japanese/Chinese). Example trajectories for each source region is shown here. The table below summarizes the preliminary statistics for each source region. Please note that this list is still being analyzed and refined. The histograms at the bottom show that for the 2 most Northern source regions, the plumes are sampled mostly between 4 and 6 km. For the other three regions, the only similarly sampled during TRACE-P, most of the plumes are encountered above 6 km. For all the INTEX-B Asian plume encounters, the peak sampling altitude is the 6-8 km layer. This is a different result than found in *Heald et al.* [2003], where the peak in the altitude of the plumes encountered during TRACE-P was in the lower troposphere.

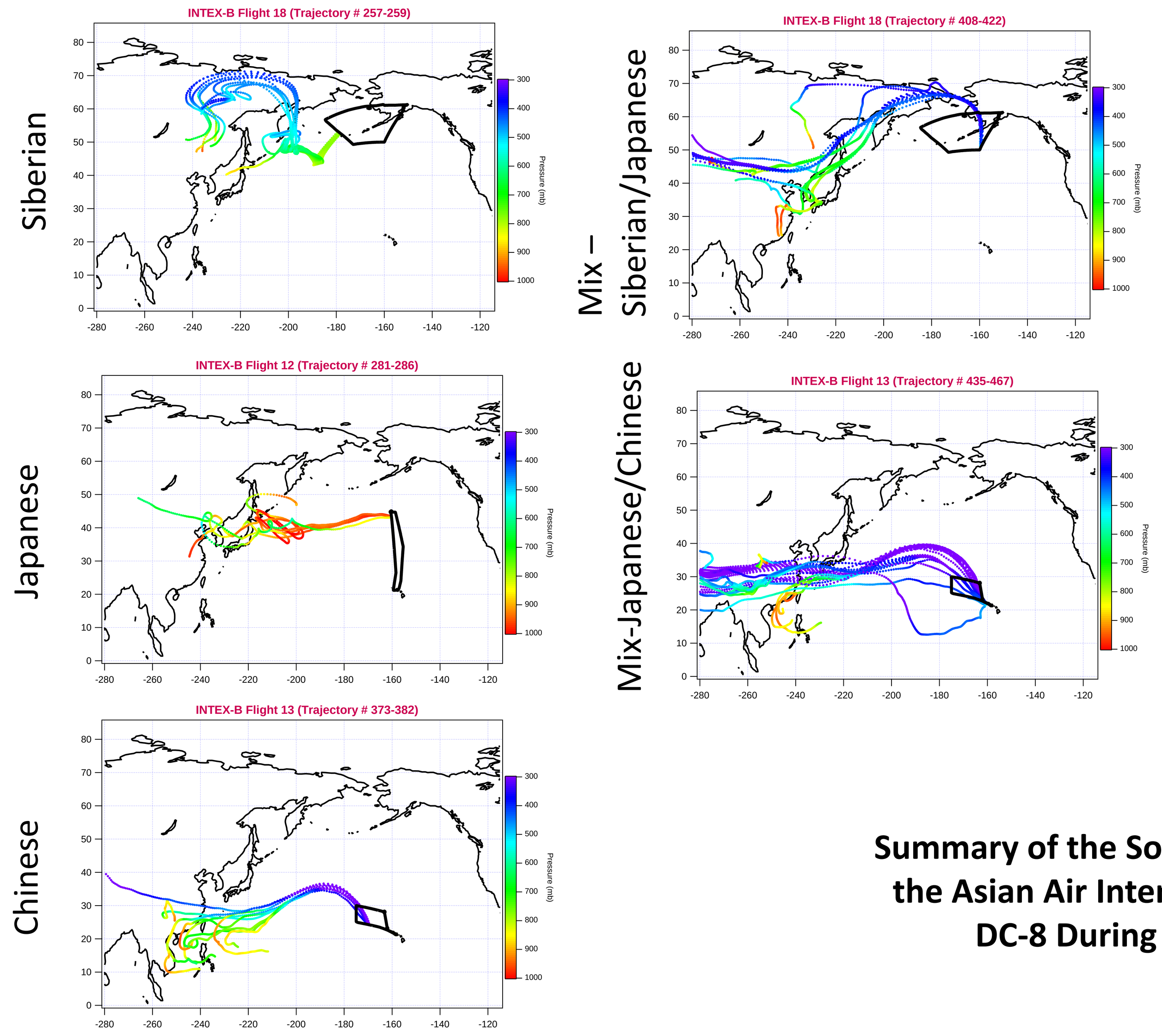
The profile plots at right show examples of the aerosol and chemical species measured during INTEX-B compared to similar measurements made during TRACE-P from both the DC-8 and the P-3B. These plots show the evolution of the outflow from nearby the source regions (TRACE-P) across the Pacific where it is intercepted by the DC-8 up to 10 days later. Since the Japanese (INTEX-B) source region can be approximated by the latitude box between 30N and 50N, the TRACE-P data is partitioned into 2 regions, North and South of 30N. This allows for a comparison of the outflow from Japan with the outflow from China. The northern Siberian and Mix-Siberian/Japanese data is not presented here since the TRACE-P study area did not include this region.

Not surprisingly, the TRACE-P air masses showed much higher concentrations of pollution tracers than does the INTEX-B data. For example, SO_2, a product of anthropogenic pollution decreases by a factor of 2-4 in the 0-2 km layer between the two study areas. Dust tracers, such as Mg^{2+} and Ca^{2+} were greatly enhanced below 4 km at the Asian coast over the middle of the Pacific, however above 4 km, the mixing ratios are about the same between the TRACE-P and INTEX-B data.

The gas Halon-1211 (CF_2ClBr), which has been found to be an excellent tracer of Asian outflow since China is one of the few countries to still produce it (Blake et al., 2003) showed an increase between TRACE-P (2001) and INTEX-B (2006) owing to its long lifetime. It increased by approximately 10%. Blake et al. (2003) report that it increased by 50% between 1994 and 2001 right off the coast of Asia. Tetrachlorethene (C_2Cl_4) continues to decrease dropping from measured mean concentrations just off the coast of 4-12 pptv down to less than 1 pptv at any altitude.



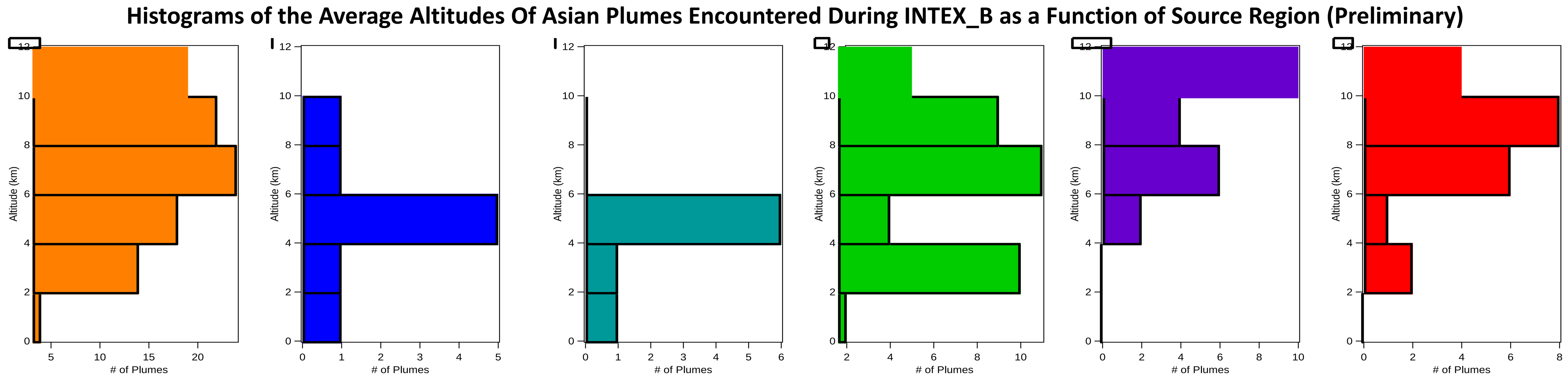
Example Source Regions From INTEX-B Data



Summary of the Source Regions of the Asian Air Intercepted By the DC-8 During INTEX_B

Source Region	# of Intercepts	Time (minutes)
Siberian	12	193
Mix-Siberian/Japanese	13	175
Japanese	55	695
Mix-Japanese/Chinese	32	611
Chinese	26	435

Histograms of the Average Altitudes Of Asian Plumes Encountered During INTEX_B as a Function of Source Region (Preliminary)



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Heald, C. L., et al., Transpacific transport of Asian anthropogenic aerosols and its impact on surface air quality in the United States, *J. Geophys. Res.*, *111*, D141310, doi:10.1029/2005JD006847, 2006.